UNUSUAL GROUND WATER SUPPLY CONDITIONS AT BATON ROUGE, LOUISIANA[1]

By L. R. Howson

Many localities have no ground water supplies available at any cost, others but limited ones, and a few are blessed with adequate and satisfactory supplies from underground sources, but there is no section which can furnish ground water supplies more satisfactory in quality and under so many varying conditions of pressure, temperature, yield and depth as are found in the Mississippi River Delta near Baton Rouge, La. The Baton Rouge Water Works Company has been the pioneer in exploring the underground water resources of this locality, which now furnishes such an abundant supply for the city of Baton Rouge and the large oil refineries and other industries there.

The source of all ground water is rainfall, a large part of which is absorbed by the ground and travels slowly through the underground strata toward the water courses or other outlets. Based upon the gathering capacities of other watersheds where records are available, it is probable that from 20 to 40 per cent of the rainfall reaches the subsoil. Applying this minimum to the average Louisiana annual rainfall, each 1000 acres of porous strata exposed to rainfall collection will permit the withdrawal of 1,000,000 gallons per day continuously from the strata at some lower point without depleting the storage in the ground.

Louisiana and Southern Mississippi can be divided into three sections so far as the water collecting properties of the soil are concerned.

First. In the area from Baton Rouge south to the Gulf of Mexico the land lies at an elevation of 0 to 20 feet above the sea level. The area is level, quite marshy, and has a decidedly impervious topsoil. This area is of little value, either for ground-water collection or for its transmission, and accounts for the great depth to which New Orleans wells must go to strike water-bearing strata.

[1] Read before the Illinois Section on March 26, 1919.

Second. The area from Baton Rouge to a distance of 25 miles to the north rises from 20 feet to 100 feet above the sea level. The soil is sandy, the topography more rolling, and the area is excellent gathering ground for water. This area embraces about 1000 square miles.

Third. Just south of the Louisiana-Mississippi line the land becomes more rolling and rises quite rapidly to an elevation of from 200 to 400 feet above the sea level. The soil above elevation 100 contains a large proportion of gravelly material, and therefore presents a good exposure for the collection of rain water as the elevation increases. This surface condition prevails over nearly 20,000 square miles. The gravel strata are separated by tight impervious clay strata, which prevent the interconnection of the porous strata, and account for the variations in static pressure.

The porous soil which furnishes a good medium for the collection of the rainfall and its transmission extends over an area approximately half as large as the State of Illinois.

All of the gravel and clay strata dip toward the south at a slope of about 20 feet to the mile, so that the porous stratum outcropping near Jackson, Miss., at 400 feet above sea level is penetrated at Baton Rouge, 125 miles to the south, at 2050 feet below sea level.

With a knowledge of the above conditions, it would be natural to expect that plentiful ground water supplies would be available, and this is the case. At Baton Rouge, which is about 40 feet above the sea level, the Water Company's wells furnish the following data:

a. Wells 200 to 400 feet deep have a static elevation near sea level; the temperature of the water is 64°, and it is high in organic matter.

b. Wells 800 to 900 feet deep penetrate a 50-foot layer of sand, which yields a plentiful supply of water whose temperature is 72°. The static level is 35 feet above sea level, and tubular wells from 6 to 12 inches in size will show a specific capacity or yield for each foot the static water level is lowered, of from 10 to 12 gallons per minute.

c. Wells 1320 to 1350 feet deep penetrate a sand layer in which the static water level rises to 110 feet above the sea level. The water has a temperature of 85°, and wells have a specific capacity of but from 1 to 2 at the water works, and $6\frac{1}{2}$ at the city well recently drilled.

d. At 2050 feet a 60-foot sand layer is penetrated which produces wells having specific capacities of 12 to 15, and a temperature of 92°. The static water level is 160 feet above sea level, or 120 feet above the ground surface.

The Water Company had exhaustive tests made of its wells in 1916, at which time it was recommended that the future increase in supply be derived from the 2000-foot depth. Acting on that recommendation, the Water Company let a contract for drilling one well to that depth.

The well was drilled by the rotary process. It consists of 915 feet of 12-inch, 934 feet of 10-inch, 44 feet of 8-inch casing, and a 70-foot strainer. The latter consists of perforated well casing wound with brass gauze. The entire well was drilled and tested in sixty-two days, or at an average rate of nearly 34 feet per day.

No rock has been encountered in any of the wells sunk thus far, and the holes are cased the entire distance. In wells of this depth and high flow the friction becomes important, and it was thought at the time of the report that the largest casing that could be successfully handled would be 8 inches for the top 1300 feet, with 6 inches for the bottom 700 feet. It was estimated that such a well would yield about 840 gallons per minute with a free flow at the ground surface.

When the well was sunk, the contractor, who is one of the most experienced rotary well drillers, used the 12-inch, 10-inch and 8-inch sizes, and secured a flow of 1100 gallons per minute at the ground surface, the increase being due to the smaller friction losses in the larger casing.

The well has a static elevation 120 feet above the ground, or 160 feet above the sea level.

The contractor first ran a 10-inch fishtail drill down until he located a suitable foundation in tough blue clay for the 12-inch casing at a depth of 915 feet, then reamed the hole to 16-inch size, slushed the hole to insure its standing open, and inserted the 12-inch casing. This slushing is accomplished by pumping a mixture of clay and water to the bottom of the hole. As it passes upward outside of the pipe the clay particles seal the sides of the well hole and by their cohesive properties preserve the well bore until the casing can be inserted and lowered to position.

The assembling and lowering of 915 feet of 12-inch pipe required but 7½ hours. The casing was allowed four days for the sand to set around it before drilling for the 10-inch casing was started, in a manner similar to that described for the 12-inch casing. Similar methods were followed for the 8-inch casing and the 70-foot strainer.

The drilling penetrated 14 separate sand strata, each from 5 to 194 feet in depth, all of which were separated from those adjacent

by thick layers of tough blue clay, which effectively cut off intercommunication of the water. Accordingly, in each layer the pressure of the water would depend upon the elevation of the outcrop of the stratum in which it was found.

In the report made to the Water Company on additional water supply it was recommended that the future supply be taken from the 2000-foot depth, and it was thought that the sinking of one or two wells would make it possible to shut down the pumps and supply the city of 25,000 people during the night by the pressure from the wells. One well only was sunk in 1916, and for about two years it has discharged directly into the distribution system for about 6 hours during the night, delivering at a 300,000-gallon rate and maintaining 30 pounds pressure. This practice has recently been discontinued on account of the pressure required for automatic sprinkler systems. If a second well was sunk, the two wells could furnish this amount of water with about 40 pounds pressure on the mains. During the day the well discharges into the suctions of the pumps which are under pressure up to a 1,500,000-gallon rate.

The ground waters of this district vary in temperature and pressure directly with the depth. The variation in temperature is important upon the well yields, for the fine sand of Louisiana with water at 92° will transmit the water nearly $1\frac{3}{4}$ times as rapidly as the same kind of sand in Illinois with the temperature about 50°.

All wells in Louisiana do not furnish good water, although those near Baton Rouge yield a soft water of excellent quality. At some points salt wells have been found. The occurrence of salt water is, however, confined to small areas and is probably accounted for by a depression filled with salt water and without an outlet left during one of the recessions of the ocean in the formation of the lower Mississippi Valley and the Gulf Coast. This underground reservoir is under pressure from its northern outcrop and when tapped yields salt water.

A large number of wells have been drilled in and near Baton Rouge in addition to that of the Water Company, the most important being the group of 14 wells drilled by the Standard Oil Company to supply cooling and condensing water for its oil refinery, which is now the largest in the world. These wells furnish nearly 5,000,000 gallons per day.

On account of the relatively low cost of sinking wells by the rotary process, a great many farmers have drilled wells to the 1300-foot

depth, and have water piped under pressure for farm and household uses. In pre-war times an 8-inch and 6-inch well 2000 feet deep, could be drilled, including casing, for $4000.

One peculiar phenomenon was observed in testing the wells in and around Baton Rouge. The tests were made at the time when the highest water stages ever recorded on the Mississippi at this point were prevailing. All of the wells tested in the 900-foot and 1300-foot strata had static elevations from 5 to 15 feet above those observed when the wells were drilled a year or a few years before, thus indicating that there is probably some connection between the river and the sand strata at some point between the outcrop and Baton Rouge.

It is probable that wells with still greater yield, higher temperature, and rising to still greater static elevations can be drilled near Baton Rouge, but, so far, 2000 feet is the greatest depth penetrated. The author knows of no other section of the country which has such a variety of ground water sources from which to choose its supply.

The author is indebted to W. P. Connell, President of the Baton Rouge Water Works Company, and to W. M. Eberhart, well contractor, for information concerning the methods and progress on the large 2000-foot well.

DISCUSSION

L. R. Howson: In reply to questions the author stated that any well water from the Baton Rouge district has a temperature which is too high for ordinary domestic use. The lowest temperature is 72°, from the 900-foot depth. The only other source than wells is the Mississippi River, and this was for many years the source used. The river was abandoned for the wells on account of the difficulty of operating the pressure filters. The summer temperature of the river water is also high. The question, therefore, is between using water of 72° or 92°, either of which requires artificial cooling before use for drinking purposes. The company pumps it into the mains at 92°. The water is very warm when drawn from the tap. There is very little temperature drop in the mains, which are laid at shallow depth.

The depth at which the temperature of a well begins to rise is largely a question of geological formation. Ordinarily, deep wells, even in this locality, have somewhat higher temperature than shallow ones. The unusually high temperatures at Baton Rouge, however, are due to the underlying deposits of sulphur and are typical of all wells in that locality.